REX2024
PRCI Research Exchange

PRCI-REX2024-082: Eddy Current Array use in detection of hard spots in line pipe

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PRCI LEADING PIPELINE RESEARCH

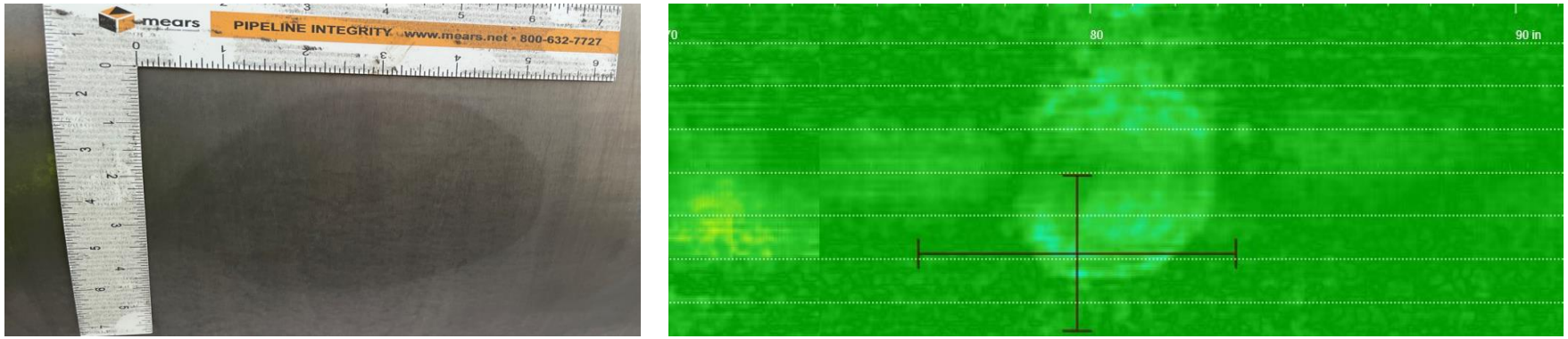
Pipeline Research Council International

Overview

- Background
- How hard-spots were verified in the past
- New way to quickly screen for hard-spots
- Scanning demonstration (video)
- Circumferential Magnetic Anomalies (CMA)
- Multiple threats in a single pass
- Enbridge hard-spot in-ditch process
- Conclusions and Ideas for the future

Background

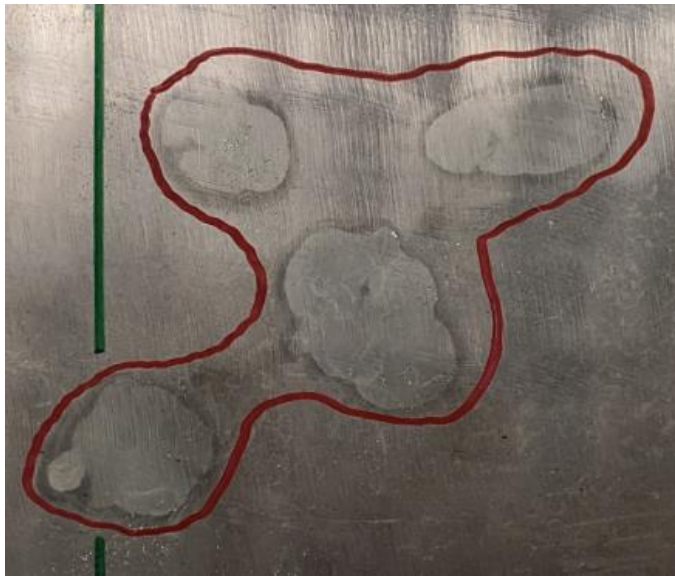
- Hard Spots are manufacturing defects of localized high hardness due to inadvertent quenching during final hot rolling of steel plates.
- API 5L criteria for hard spot: >327 HB and larger than 2” in any direction.
- Smart pigs can detect hardness variations during in-line inspection, but often with mixed results – “New” types of hard-spots found as recent as late 2023
- Many operators ran hard-spot tools in the 1980’s and 1990’s and until recently were not looking at hard-spots on a regular basis



ECT Scan and Etching of AO Smith Pipe Body Hard Spot (338HB).

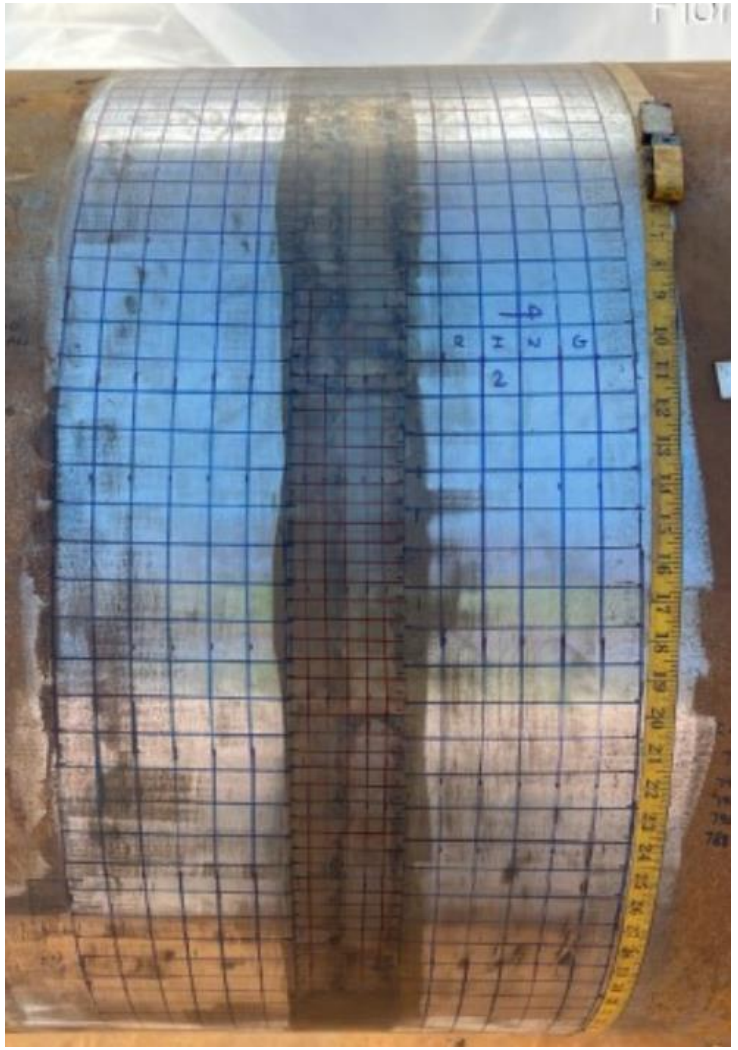
How hard-spots were verified in the past

- ILI runs were completed to locate potential hard-spots
- Sites were excavated and the location was polished for etching
- Nital (mixture of nitric acid and alcohol) applied on the steel surface will reveal the microstructure and the presence of hard spots
- Nital etching requires extensive surface preparation (sandblasting, grinding, polishing) and can be challenging at the bottom of the pipe (6 o'clock)
- Relies solely on ILI accuracy for location
- Overall a very time-consuming inspection that cannot be scaled to a full pipeline joint



How hard-spots were verified in the past (Cont)

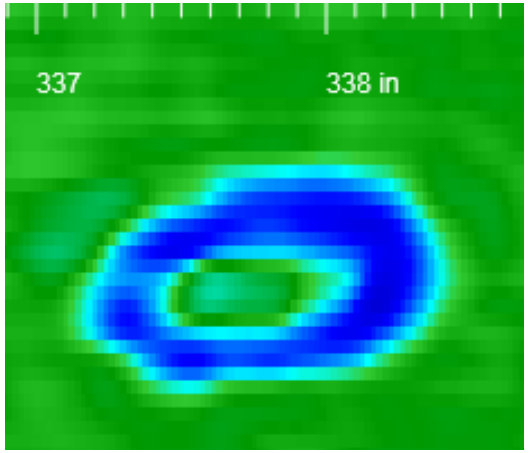
- **Detection with nital etching is followed by hardness measurements**
- **Multiple quantitative techniques available for hardness measurement:**
  - Rebound (Leeb)
  - Indentation (Rockwell, Brinell, Vickers)
  - Ultrasonic contact impedance (UCI)
- **Lab testing for Enbridge showed that Leeb D method provided the most consistent results on actual pipeline dig situations.**
- **Requirement to take measurement every 1” or ½” also makes this very time-consuming**



New way to quickly screen for hard-spots

- **The change in the steel microstructure comes with a change of electromagnetic properties**
- **The eddy currents are affected by these changes and will detect the hard areas**
- **Spyne is the ideal tool for the rapid screening of a joint to localize the hard areas (40ft joint takes approx. 2hrs)**
- **Direct assessment with Spyne showed more sensitivity than in-line smart pigs**
  - Many more indications were noted with Spyne that were not called out by the ILI tools
  - Through information sharing with ILI Vendors they were able to adjust the filters on the ILI to locate additional potential hard-spots such as the CMA features

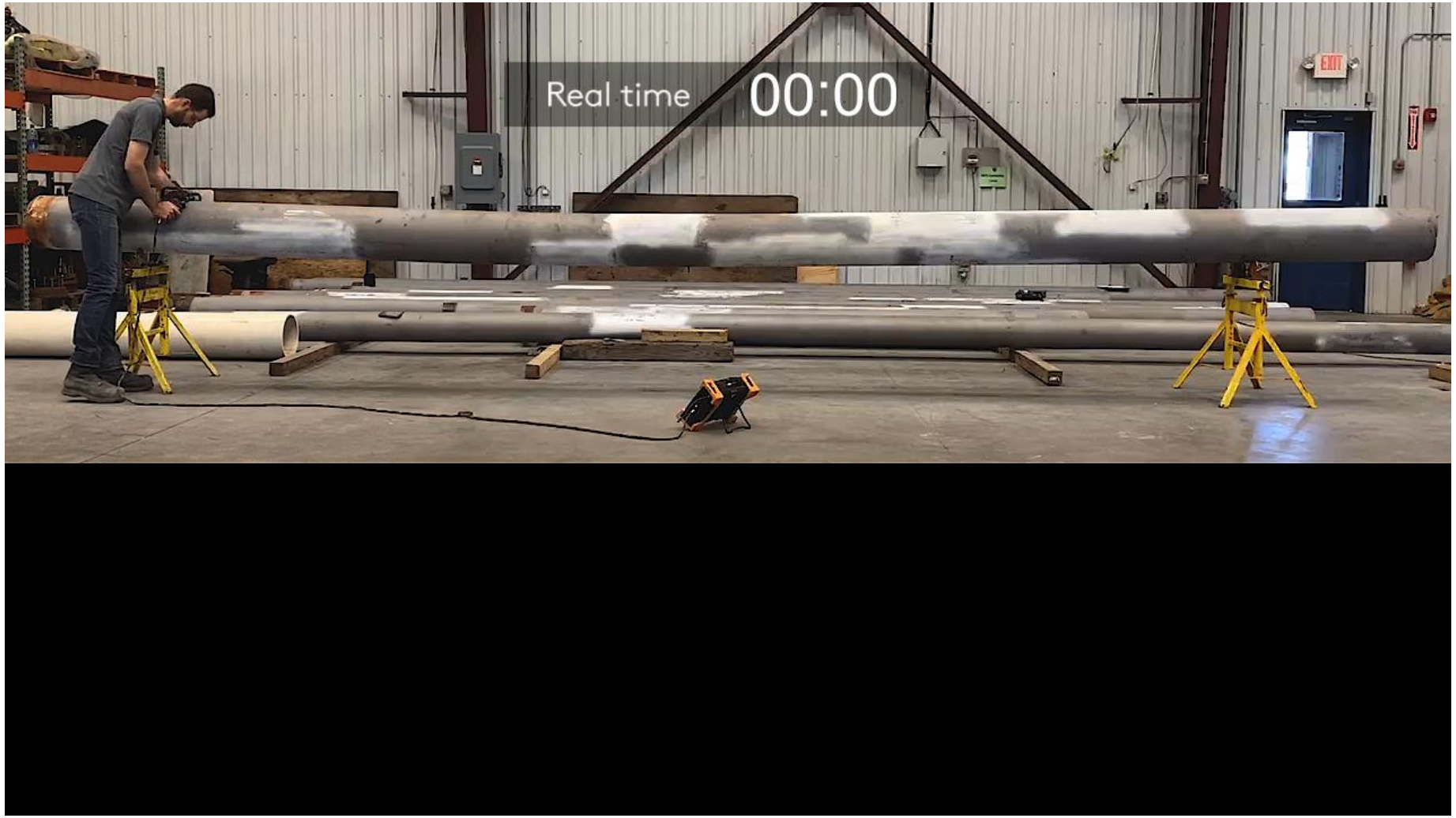
1 in² hard spot



New way to quickly screen for hard-spots

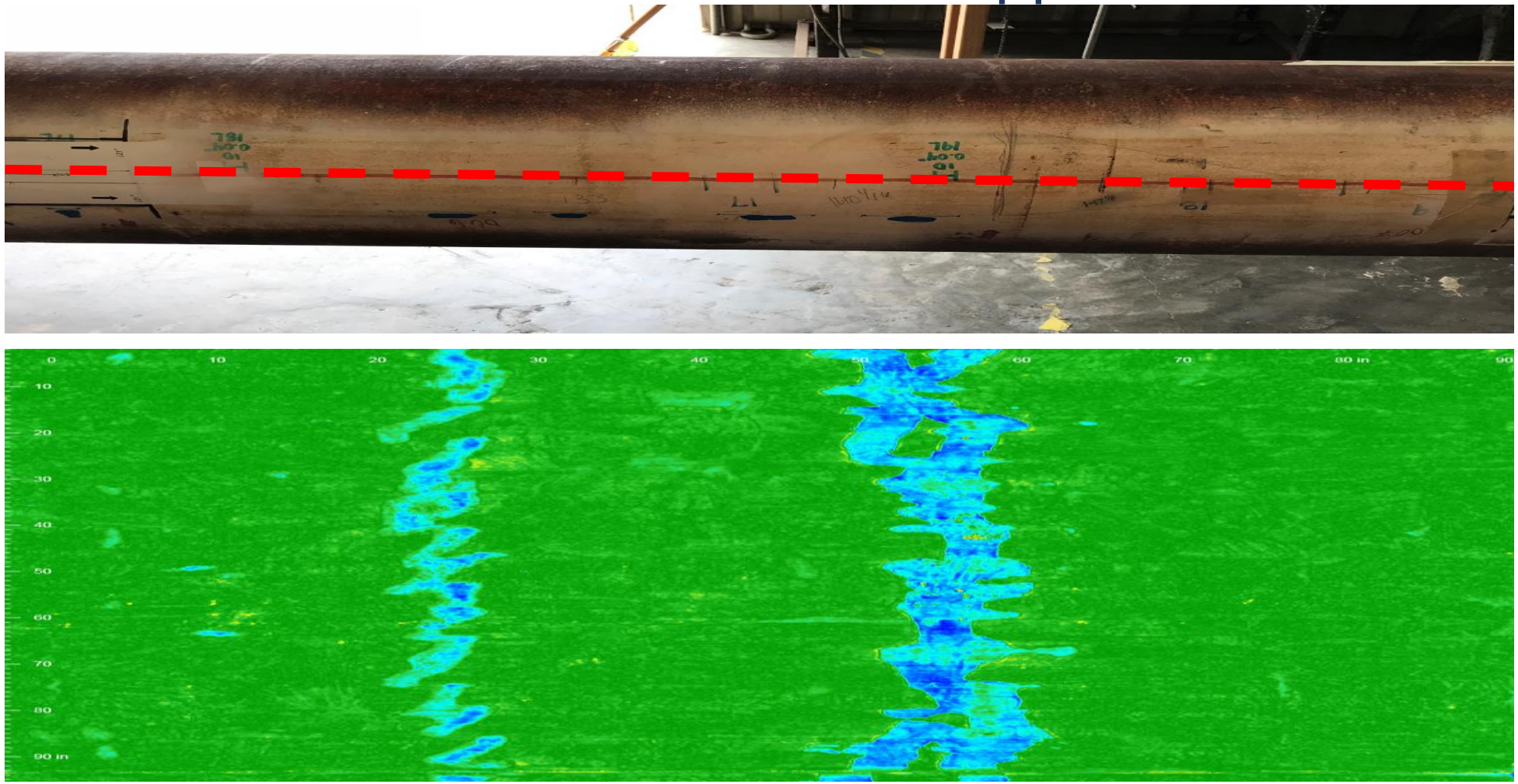
- **Advanced eddy current array (ECA) can be used for the detection of Hard-Spots:**
  - More efficient than existing polish and etch methods
  - Reliable/repeatable data and reporting
  - 200 mm (8 in) of coverage in one pass
  - Max speed up to 600 mm/s (2 ft/s)
  - Minimum diameter: 150 mm (6 in) up to flat
  - User friendly software that allows even a novice user to scan and locate features.

Scanning Demonstration



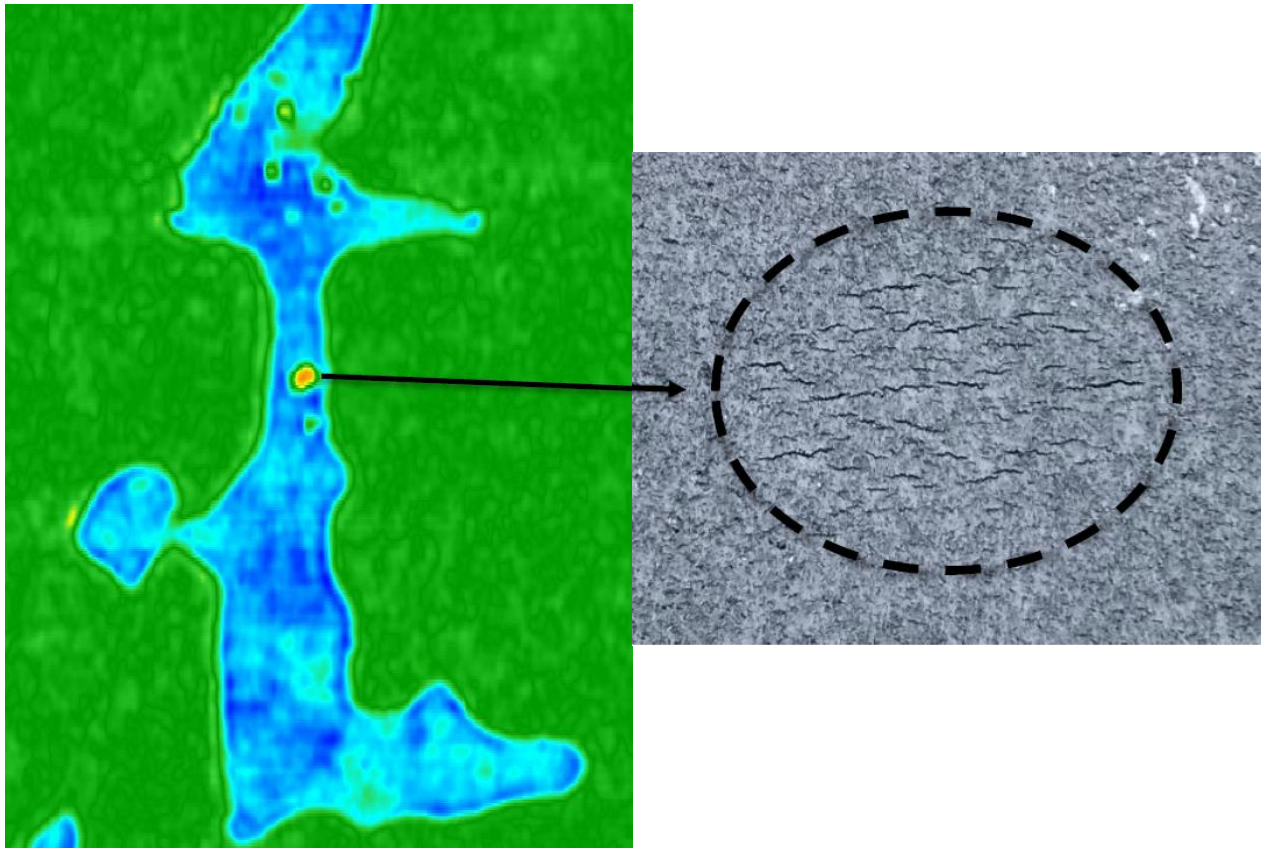
Circumferential Magnetic Anomalies (CMA)

- Some hard areas can cover the entire circumference of the pipe



Capable of detecting multiple threats in a single pass

- The C-scan reveals small red indications that appear preferentially in the hard areas
- The crack indications (positive signal, red) have a phase shift of 180° relatively to the hard spot indications (negative signal, blue)
- Spyne can be used as a replacement of magnetic particle inspection



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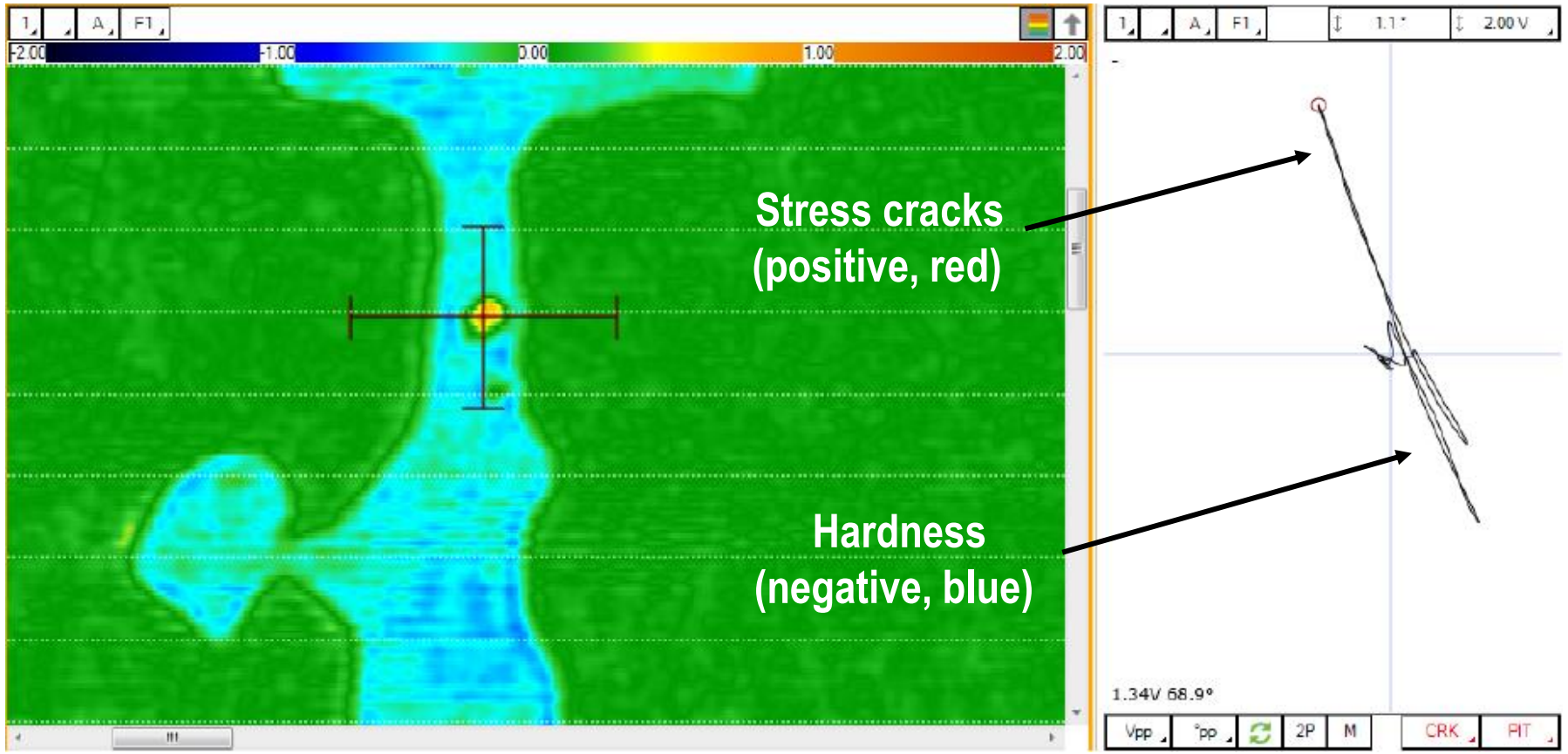
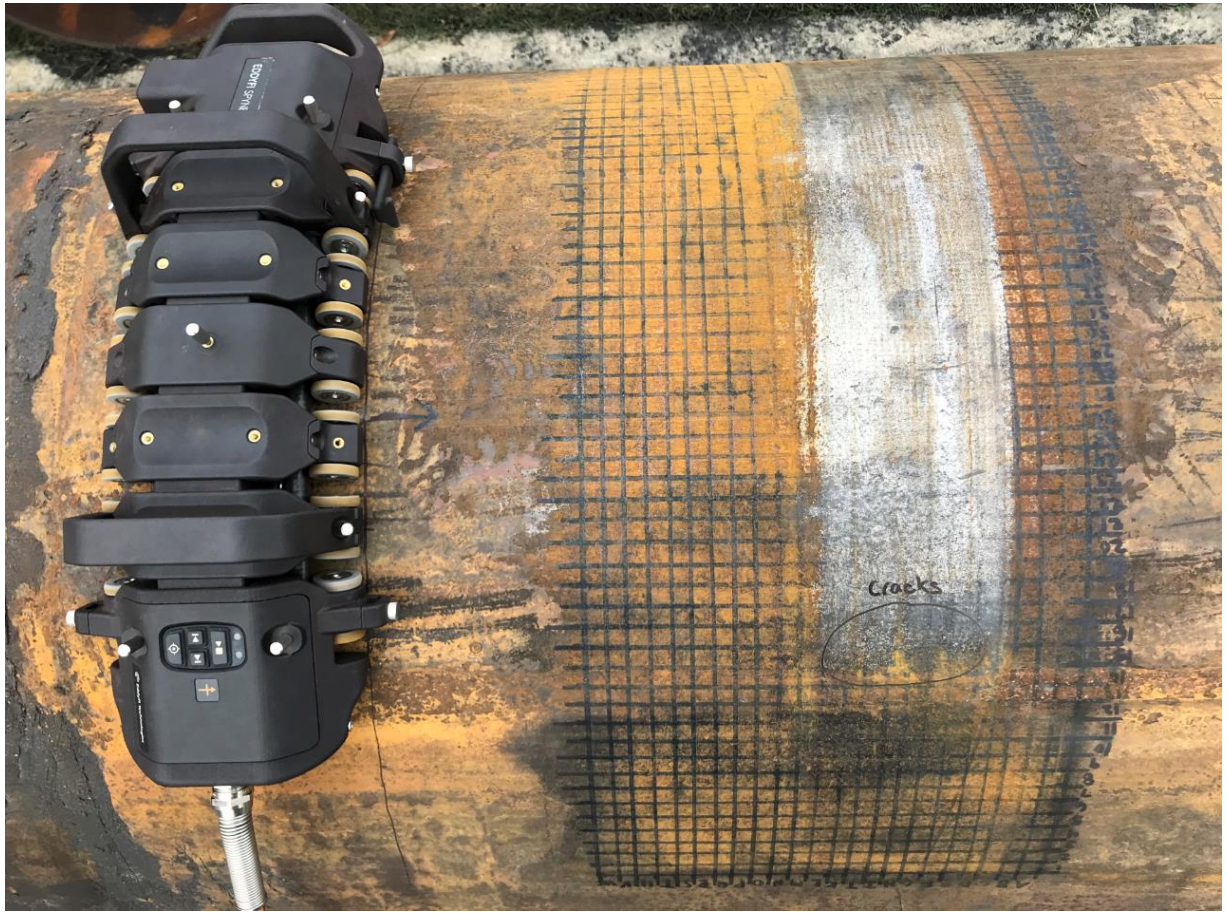


Enbridge Hard Spot Process

- Coating removal and sandblasting
- SET/ECA (Spyne Scan)
- White painting
- MPI
- UT Lamination Scans
- Grinding and polishing
- Nital etching
- Hardness measurement



Conclusions

1. The industry thought that hard-spots were no longer a threat until recent events and regulatory interest
2. Existing assessment methods were time consuming and not suitable for large area inspections
3. Advances in ET technology made SET/ECA suitable for large area inspection
4. Pipe can be inspected for Hard-spots as well as SCC in a single pass
5. Verification with Nital and portable hardness is still needed in order to validate the findings
6. Collaboration with ILI vendors allowed for the enhanced grading that has identified previously undetected hard-spots
7. Renewed interest in the threat is leading to further development in the technology

Could we soon see a correlation between impedance and hardness?

thank you

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